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Intelligent Use of M&S Is Good T&E Business

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Operational test and evaluation "…does not include an operational assessment based exclusively on— (1) computer modeling; (2) simulation; or (3) an analysis of … program documents." (U.S. Code Title 10, section 2399). Yet we use not only realistic tests but also models, simulations, and the discipline of modeling and simulation (M&S) to inform our evaluations. We could easily assume a lot about M&S, but intelligent use of M&S in T&E requires a disciplined approach in both planning and confidence building.

David W. Duma

Evaluators often rely on M&S results to garner the significance of test results. Complexity of tests, limited test articles and test range assets, and safety considerations often drive this. In a systems-of-systems test, all systems or targets need to be present or represented. Properly executed tests provide the data upon which rest the operational assessment of the system and the validation of its models. M&S provides a measure of confidence that sufficient and appropriate tests will be executed, supports detailed test planning and rehearsals, and facilitates post-test analyses.

The Department of Defense (DoD) Instruction 5000.61 on DoD M&S Verification, Validation, and Accreditation (VV&A) was signed in December 2009 (and is considered in depth in another article in this journal). It states as policy that "Models, simulations, and associated data used to support DoD processes, products, and decisions shall…" (a) "… undergo verification and validation (V&V) throughout their lifecycles" and (b) "… be accredited for an intended use." Note that unlike the prior version of the Instruction, it is not just some DoD processes, products, and decisions that require VV&A for their intended M&S use.

Proper application of the V&V processes, to clearly show model assumptions, limitations, and constraints, provides confidence that we can accredit their use for specific purposes in T&E. The level of V&V must be appropriate to the proposed use, and to the maturity of the system and the models. In general terms, less V&V is required for accreditation of uses that are intended to give insight into trends than for applications intended to support decisions upon which the lives of those in the field will depend. Some intended uses that might require less VV&A are for data to indicate testability of requirements, or adequacy of the infrastructure, or early test planning. Some that require more V&V include use of M&S to supplement live data and post-test analysis of results.

Complex systems require rigorous VV&A planning. The Missile Defense Agency recently (spring 2010) updated the Integrated Master Test Plan (IMTP) for the Ballistic Missile Defense System (BMDS). The IMTP is a 5-year plan with a 6-month update cycle. This allows it to identify test events across the Future Years Defense Plan, yet be responsive to results of test events or changes in executive guidance.

The IMTP is data driven to identify the critical test factors—the sensitive data elements and specific "critical engagement conditions"—needed to provide confidence that the BMDS and its system-level elements are accurately represented. It also identifies "empirical measurement events"—those events needed to provide confidence in system performance but not necessarily critical to M&S verification and validation. To date, over 100 conditions or events have been identified for the nine system-level elements that make up the BMDS.

The Honorable Dr. J. Michael Gilmore, Director of Operational Test and Evaluation (DOT&E), approved this IMTP. He stated in testimony before the House Armed Services Committee, on April 15, 2010, "If the MDA can execute the revised IMTP, the data needed to validate models and perform quantitative assessments of BMDS performance will become available."

Naval ships and submarines are among the most expensive and largest procurements in the DoD. The first unit produced is an operational unit rather than a prototype. Yet we must subject them to "realistic survivability testing"—"testing for vulnerability of the system in combat by firing munitions likely to be encountered in combat (or munitions with a capability

similar to such munitions) at the system configured for combat…" (U.S. Title 10, section 2366). Waivers for firing munitions at the first units have been granted in all cases to date, but alternative test plans must be approved by DOT&E.

Since 1987, live fire T&E of shock-hardened (e.g., combat) vessels has required Full Ship Shock Trials (FSST). These tests help evaluators and the programs learn lessons that can improve the survivability of the vessels subjected to the shock of underwater explosions. Lessons learned include design flaws, fabrication deficiencies, and capabilities of systems and crews to recover mission capability after such an event.

A FSST detonates several charges at standoff distances and depths to create shock loadings at fractions of the design criteria. The FSST vessel is fully manned and underway with all critical systems operational. The vessel is first "groomed"—for example, some noncritical less-rugged systems are removed as part of careful preparation and inspections.

State-of-the-art simulations (using finite element models) offer the potential to augment FSST vulnerability and survivability data with data that cannot be safely obtained from a FSST. However, real questions remain regarding the credible use of M&S to determine when equipment failure occurs as a result of shock loading.

The Virginia submarine class FSST cancellation was approved by DOT&E. The decision was based on its highly shock-hardened design, VV&A of the transient shock analysis method, and tests at the Aberdeen Test Center Underwater Explosive Test Facility. These tests included a full-scale model of approximately one third of the weapons handling module at shock levels higher than those normally achieved in FSSTs. This testing revealed things that a FSST could not have done.

The CVN 78 program is developing an advanced modeling and simulation capability to augment reduced scope shock testing of CVN 78. The Navy has developed a memorandum of agreement on the elements of the process. DOT&E intends to withhold its decision to concur with the implementation of the memorandum of agreement until the feasibility of the M&S is demonstrated. This is anticipated in FY13.

An alternative approach to FSSTs under investigation is use of compressed air guns to replace the explosives as the elements that mechanically excite the vessel. Unlike explosives, compressed air guns can be reused. However, there are differences. Shock waves from air gun arrays are currently less abrupt and energetic than the explosives. The mechanical responses are initially more localized and then propagate through the length of the vessel. It may be appropriate to conduct some side-by-side full ship testing using explosives and the air guns, with parallel analyses to investigate differences in the resulting data. This, of course, would need to be followed with analyses to assess the significance to live fire testing and evaluation and to inform future decisions on intelligent use of the simulated explosive test.

Limitations on the use of full ship shock trials coupled with the lessons learned from the mining of the *USS Princeton* during the First Gulf War have spurred the Navy to develop detailed models of shock propagation in the ship's structure and for the prediction of damage propagation as a consequence of weapon effects. These support the assessment of ship survivability for live fire testing and evaluation.

T&E practices involve the intelligent use of M&S in the planning, conduct, and analyses of test events as well as to augment these test data. Credible use of M&S in support of T&E requires a disciplined approach to establish the level of V&V needed for confident accreditations for the variety of intended M&S uses.

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Mr. David W. Duma was appointed as the principal deputy director, Operational Test and Evaluation, on January 14, 2002. In this capacity he is the principal staff assistant for all functional areas assigned to the office. He participates in the formulation, development, advocacy, and oversight of policies of the Secretary of Defense and in the development and implementation of test and test resource programs. He supports the director in the planning, conduct, evaluation, and reporting of operational and live fire testing. He serves as the appropriation director and comptroller for the Operational Test and Evaluation, Defense Appropriation, and the principal advisor to the director on all planning, programming, and budgeting system matters.